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EXECUTIVE SUMMARY

The Hydrotech Discfilter process was operated at the Newport Wastewater Treatment Plant in Newport, NH from November 2 – 20, 2009. The purpose of piloting was to show the Discfilter process to be a viable option for tertiary water treatment at the Newport WWTP. The Newport WWTP is a secondary aerated lagoon plant that uses UV for disinfection.

The pilot study objectives were centered on total phosphorus removal. More specifically, the Discfilter process was to show its ability to consistently produce an acceptable effluent total phosphorus concentration less than 0.35 mg/L as well as produce the lowest effluent total phosphorus level as possible. During the pilot demonstration, the Discfilter was operated under normal plant conditions using both ferric chloride and aluminum sulfate to examine its applicability to the Newport WWTP.

The project was conducted for three weeks. Wastewater was pumped from former chlorine contact basins that are no longer used. During the first week ferric chloride (ferric) was used as the coagulant with influent total phosphorus levels around 3.4 mg/L. With 60 mg/L of ferric and 1.0 mg/L of Hydrex 6161 (dry anionic) polymer, the effluent total phosphorus level was 0.31 mg/L. During the second and third weeks, aluminum sulfate (alum) was used as the coagulant with influent total phosphorus conditions decreasing to an average of 3.0 mg/L. With 50 mg/L of alum and 1.0 mg/L of Hydrex 6161 (dry anionic) polymer, the effluent total phosphorus level was 0.31 mg/L. The protocol also stated that the maximum removal amount of effluent total phosphorus should be attempted. The maximum removal with 70 mg/L of ferric yielded effluent total phosphorus at 0.10 mg/L and 80 mg/L of alum yielded effluent total phosphorus at 0.17 mg/L.

The Hydrotech Discfilter would be a viable fit for the Newport WWTP capable of removing total phosphorus down below 0.35 mg/L. The Discfilter also provides operational flexibility to achieve lower total phosphorus limits (0.10 mg/l) if needed in the future without modifications to the process train.

1.0 Introduction

1.1 Discfilter Process Description with Chemical Addition

For removal of total phosphorus (TP), coagulation and flocculation tanks are used in-line up-stream from the Discfilter unit. A coagulant is added to the influent stream and will enter the coagulation tank. The coagulation tank has a hydraulic retention time (HRT) of three to eight minutes depending on the flow rate. This is the average length of time that the coagulant should remain in that tank while being mixed. Once the HRT is met the coagulant will exit the coagulation tank and enter the flocculation tank. Introduced to the inlet of the flocculation tank is a polymer. The coagulant and polymer will then be mixed in the flocculation tank for another HRT of about five to fifteen minutes depending upon flow rate. While mixing commences in the flocculation tank, the polymer will bond with the coagulated particles and create floc which will aide in the removal of TP. After the HRT is met the newly formed floc will exit the flocculation tank and head down-stream by gravity into the Discfilter. This process can be seen in Figure 1.

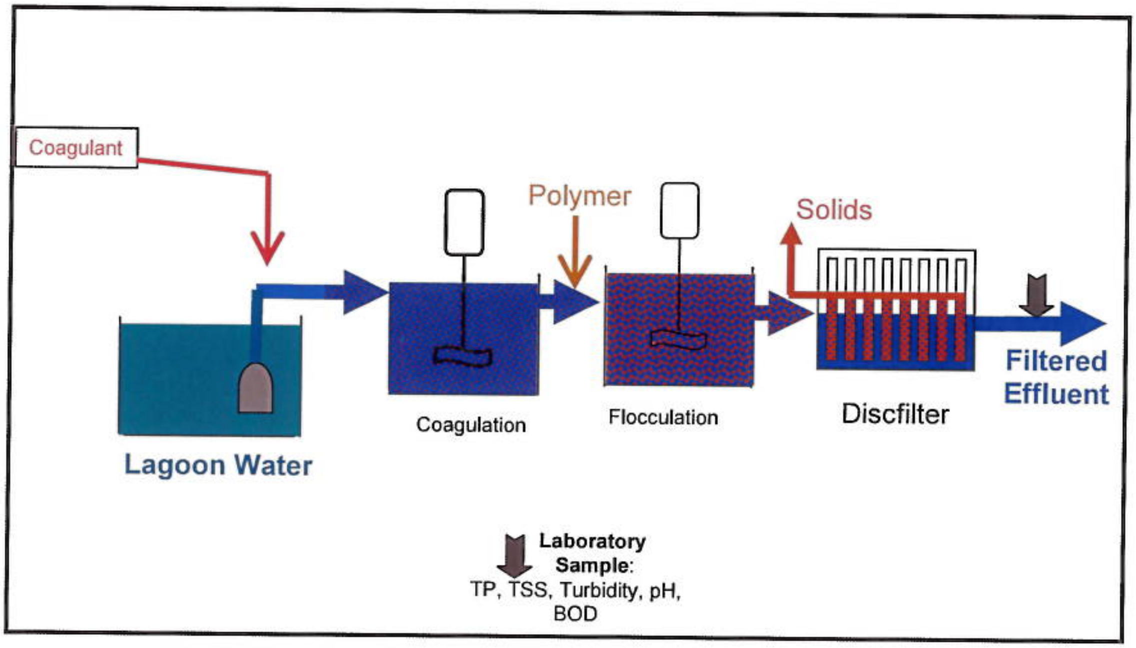

Figure 1. Discfilter Process Description

The Discfilter is a stainless steel constructed tank with fabric membrane filter panels used to remove TP. Flow enters the center drum of the Discfilter where it flows by gravity into the filter segments (Figure 2). Solids are separated from the water by the filter panels mounted on the two sides of the disc segments. The filter panel material (polyester) has a woven pore size of 10 - 40μm (depending upon application). The solids are retained within the filter discs while the clean water flows to the outside of the discs into the collection tank. The filtered water reservoir eliminates the need for an independent backwash water supply since the suction side of the backwash pump is piped directly to the reservoir. During normal operation, the discs remain static. The static period is the length of time between backwashing in which the discs are stationary.

Backwashing is initiated when the head differential between the inlet water level and the clean water reservoir increases to the point that the inlet water comes in contact with a sensor probe. Once the backwash is initiated, a preset timer allows the disc to rotate through the backwash spray sequence enough that the submerged panels are sufficiently cleaned; this occurs only after the sensor probe has signaled it is no longer in contact with the inlet water. Solids are backwashed into a collection trough as the discs are rotated. The counter-current flow path and spray headers ensure a thorough cleaning of the filter media with minimal water use. Backwash spray is provided via the oscillating header with nozzles that can be removed, cleaned, or replaced without the use of tools.

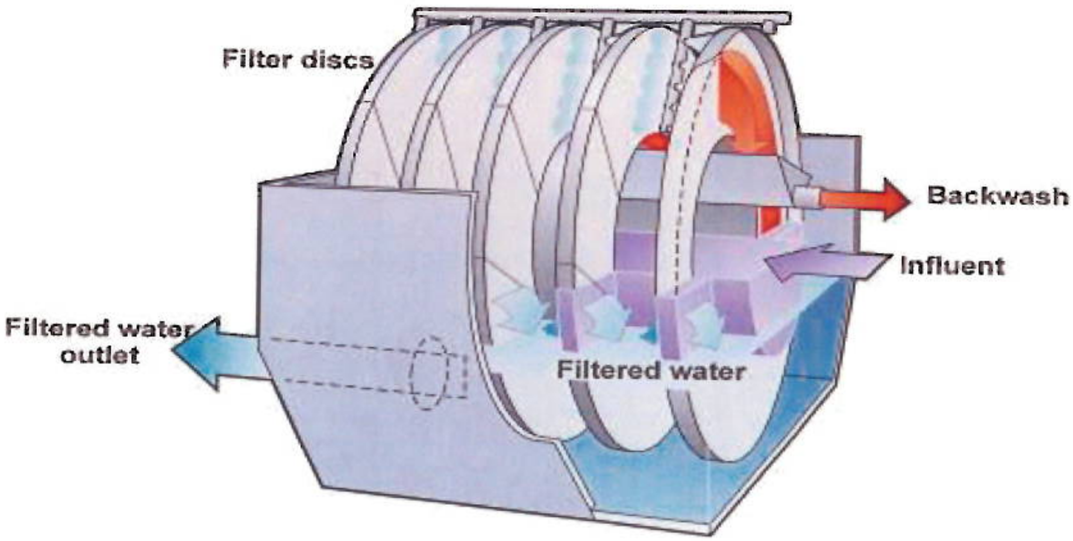

Figure 2. Discfilter Flow Diagram

1.2 Discfilter Pilot Unit Specifications

Table 1. Discfilter Pilot Unit Specifications

Pilot Unit Specifications	Value	Unit
Coagulation Tank		
Length	37	in.
Width	37	in.
Height	37	in.
Flocculation Tank		
Length	35.5	in.
Width	35.5	in.
Height	66	in.
Hydrotech Discfilter		
Influent Flow	17-100	gpm

Table 2. Discfilter Hydraulic Loading Rate (HLR) and Hydraulic Retention Time (HRT)

Total Panel Filter Surface Area ($ft.^2$)	Submerged Panel Filter Surface Area ($ft.^2$)	Pilot Influent Flow (gpm)	Hydraulic Loading Rate ($gpm/ft.^2$)	Hydraulic Retention Time (min)
33	16.6	17	1.0	35
		25	1.5	23
		33	2.0	18
		42	2.5	14
		50	3.0	12
		58	3.5	10
		66	4.0	9
		75	4.5	8
		83	5.0	7
		92	5.5	6

* The Hydraulic Retention Time contains the total time it takes for water to flow through the coagulation and floc tank.

1.3 Coagulant Chemical Data

The coagulant evaluated during the pilot study is as follows:

- Aluminum Sulfate [$Al_2(SO_4)_3$] (48 % wt./wt. active)
- Ferric Chloride [$FeCl_3$] (40 % wt./wt. active)

The coagulant dose in this report was calculated using the % active and specific gravity of each. This means that in all doses, this product is based on weight of each per volume of water treated (dose = mg/L H_2O treated).

1.4 Polymer Chemical Data

The polymer evaluated during the pilot study is as follows:

- HYDREX 6161 (Dry Polymer – Anionic – Product of Crown Solutions)

The polymer was made up as a one to one ratio solution (1 grams dry polymer / 1 Liter dilution H_2O).

1.5 Field Instrument Calibrations

- The bench top turbidimeter (Hach Model 2100N) was calibrated using the Stabcal method found on pages 20 – 23 of the Hach Manual for 2100N; the same standards were used to periodically throughout the study to check the instrument's calibration.

- The bench top pH meter (ORION Model 420A) was calibrated using the recommended method on page 19 of the Manual for Bench top pH/ISE meters; this is a three point manual calibration buffer method.

- The online influent turbidimeter (Hach Model OptiQuant™ SST Suspended Solids and Turbidity) was calibrated using the recommended Method 4.1.1 which can be found on page 40 of Hach Company Manual for SST Suspended Solids and Turbidity Probes (Catalog Number DOC023.54.03108.

- The online effluent turbidimeter (Hach Model OptiQuant™ SST Suspended Solids and Turbidity) was calibrated using the recommended Method 4.1.1 which can be found on page 40 of Hach Company Manual for SST Suspended Solids and Turbidity Probes (Catalog Number DOC023.54.03108.

2.0 Pilot Testing Protocol

2.1 Pilot Testing Objectives

The pilot operating parameters, testing, sampling, and analysis should be indicative of full-scale Discfilter operation for the Newport WWTP. Therefore, the testing was focused on the Discfilter's ability to treat the plant's current lagoon effluent prior to UV disinfection. The global objective of the study was to develop operating parameters needed to consistently meet an acceptable TP concentration of <0.35 mg/L on Discfilter effluent by a combination of flocculation followed by filtration with the Hydrotech Discfilter.

The objectives of the pilot testing were to:

- Establish standard Discfilter performance with respect to effluent Turbidity (NTU) and Total Phosphorus while maintaining an acceptable % backwash with respect to design flow.
- Establish optimal polymer and coagulant types and doses.
- Achieve <0.35 mg/L TP while not dropping pH <6.5 at design flow.
- Minimize operating costs while maintaining removal performance.

2.2 Sampling Scheme and Testing Schedule

All lab sample analyses were generated from grab sample collection every hour for 5-6 hours to create daily composite samples. All influent samples were collected before the coagulant injection point. All effluent samples were collected from the effluent reservoir. The influent and effluent parameters measured consisted of the following:

Analysis:
*Turbidity (NTU)
*Total Phosphorus (mg/L)
*Total Suspended Solids (mg/L)
*Biological Oxygen Demand (mg/L)
*Alkalinity
*UV_{254}
* pH

I. Kruger Inc. completed turbidity and pH analyses on all samples taken. All field instrumentation was calibrated and operated per manufacturers' recommendations to ensure reliable results. Also, standards were used to periodically check the validity of the results. All field data can be found in Appendix A. Eastern Analytical Inc. performed all laboratory analysis on Discfilter influent and effluent.

11/4 – 11/12: These days were dedicated to using ferric chloride as the coagulant of choice. The first three days were used to achieve maximum effluent total phosphorus removal. The next two days were utilized to attempt to maintain an effluent total phosphorus concentration of 0.35 mg/L. And the final day was used to perform a loading rate analysis with both 10 and 40 μm filter panels at an optimal coagulant and polymer dose to achieve ~0.35 mg/L effluent total phosphorus.

11/13 – 11/19: These days were dedicated to using aluminum sulfate as a coagulant. The first three days were again used to achieve maximum effluent total phosphorus removal. The next day was used to maintain an effluent total phosphorus concentration of 0.35 mg/L. The final day was used to perform a loading rate analysis with both 10 and 40 μm filter panels at an optimal coagulant and polymer dose to achieve ~0.35 mg/L effluent total phosphorus.

*There was no optimization period in which samples were collected and sent to a lab for analysis.

2.3 Pilot Plant Layout

The Discfilter Pilot Unit was set-up adjacent to Lagoon 1, chlorine contact basin (no longer in use), and Grit Building. A 2 hp submersible pump was used to deliver water to the unit from the contact tanks prior to UV disinfection. The Discfilter effluent gravity fed back to Lagoon 1 and the backwash was pumped back to Lagoon 1.

During testing, a coagulant was injected at a dosing spool with a static mixer 50 feet upstream of the first mixing tank. After entering the coagulation tank it then flowed by gravity into the flocculation tank where polymer was added. A picture of the pilot trailer's layout can be seen in Figure 3.

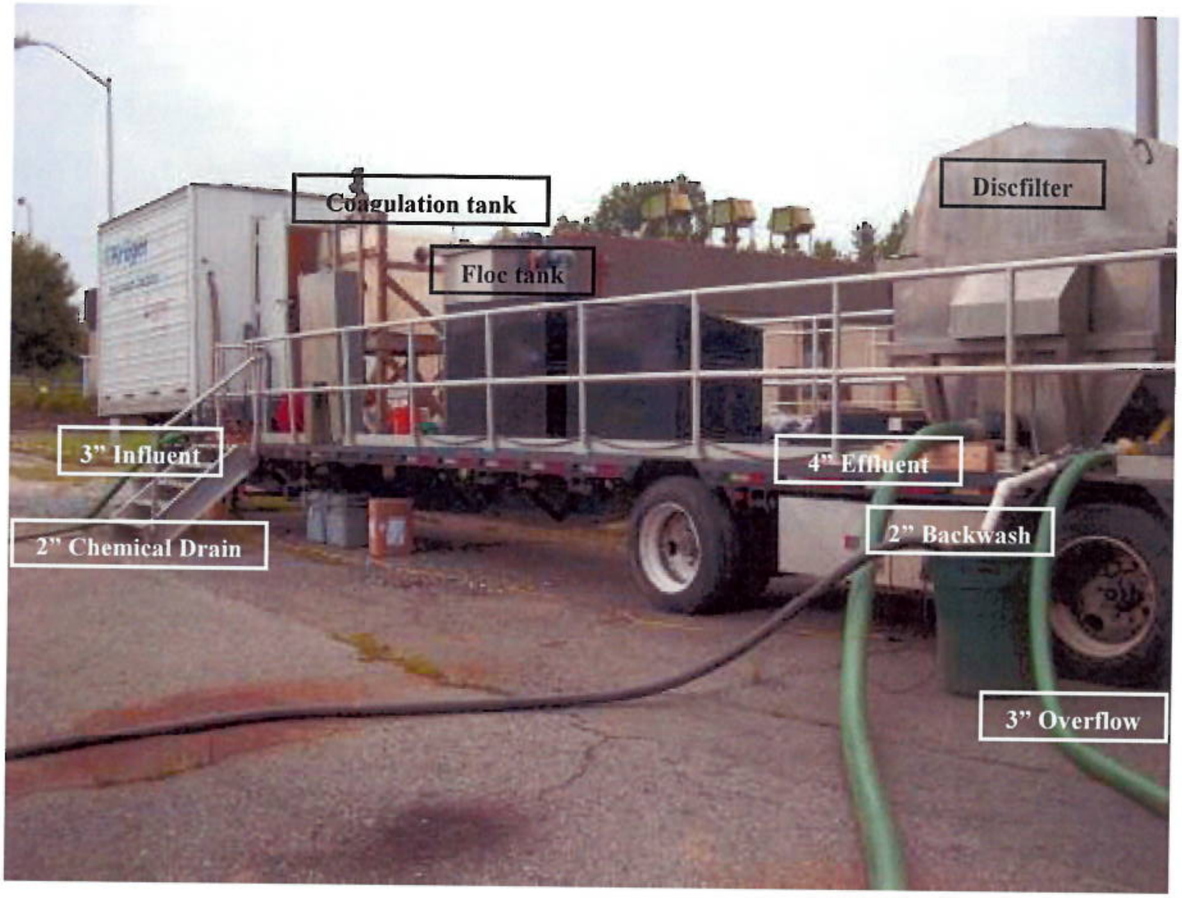

Figure 3. Discfilter Pilot Setup

2.4 Percent Backwash Test

The efficiency of the water treated through the Discfilter is based on the percent backwash (the amount of water being re-treated). To calculate the percent backwash, a 32-gallon container was placed under the backwash exit tube to collect the backwash water. A timer was set to find out the amount of time it took to fill the container with backwash water. This accrued time is multiplied by the flow (gpm) to find out how many gallons of water the Discfilter treated in that elapsed time. The 32-gallons of backwash water, divided by the gallons of water treated, multiplied by 100 will give an efficiency of how much treated water is being re-treated thus giving a percent backwash value.

$$\%\,\mathrm{BW} = \frac{BW\ Volume\ (32 - gallons)}{Total\ Gallons\ Treated} X\ 100$$

3.0 Influent Water Characteristics

3.1 TP, TSS, and BOD

The Hydrotech Discfilter treated the lagoon effluent before it passed through the chlorine contact basin (no longer used) at the Newport WWTP. The following section will discuss the water characteristics of the lagoon effluent / Discfilter influent that the plant was experiencing during the pilot study from November 2 – 19, 2009. The influent water characteristics can be seen in Table 3 below.

Table 3. Influent Water Characteristics

NTU	pH	TP	TSS	BOD
9.82	7.37	3.2 mg/L	6 mg/L	8 mg/L

3.2 Chemical Dose Calculations

The chemical dosages were measured by recording the time it took the feed pump to draw down a certain volume of chemical. This was done using calibration columns attached to the front of each chemical holding tank. The volume of chemical fed and its corresponding feed rate were then inserted into the following equations.

3.2.1 Polymer Dose

Polymer doses were calculated using the specific gravity (1.0) and the concentration of the polymer solution.

$$X_P = Q_P * \frac{3600\sec}{1hour} * \frac{C}{Q_I} * \frac{1m^3}{1000L} = {}^{mg}\!/_{L}$$

Where:

X_P : Polymer dose, mg/L
C : Concentration of polymer solution, mg/mL
Q_P : Polymer feed rate, mL/sec
Q_I : Influent flow rate, m^3/hr

3.2.2 Coagulant Dose

Coagulant doses were calculated with their respective densities and percent activities:

$$X_C = \frac{C}{100} * \rho * \frac{1000mg}{g} * \frac{Q_C}{Q_I} * \frac{60\min}{hour} * \frac{1m^3}{1000L} = {}^{mg}\!/_{L}$$

Where:

X_C : Coagulant Dose, mg/L
Q_C : Coagulant solution feed rate, mL/min
C : % of active coagulant in solution
p : Density of solution, g/mL
Q_I : Influent flow rate, m^3/hr

4.0 Discfilter Testing and Performance

The Discfilter testing took place from November 2 - 19. The testing began using ferric chloride and Hydrex 6161 polymer to achieve 0.35 mg/L effluent total phosphorus and switched to aluminum sulfate to reach the same goals. All of the tests performed were daily extended runs. For the most part, different coagulant doses were used each day to try and maintain 0.35 mg/L effluent total phosphorus. A polymer curve was conducted at the beginning to figure out an adequate polymer dose. Hydraulic loading rate curves were conducted with each coagulant as well.

* During ferric chloride runs, dose points were changed each morning and sampling began after three hydraulic retention times (1 hour). During aluminum sulfate runs, dose points were changed before leaving site at the end of the day allowing the system to reach a steady state overnight; sampling began the next day upon arrival to the site.

4.1 Polymer Optimization

The first day of testing included a polymer optimization curve using Hydrex 6161 (dry anionic) as the polymer type. A curve was conducted at 0.60, 0.75, 0.90 and 1.05 mg/L dosed into the floc tank. The rise rate remained constant at 2.0 gpm/ft^2 (33 gpm) and the coagulant dose was held at 40 mg/L of ferric chloride. The hydraulic retention time at this flow is 18 minutes through the coagulation and floc tanks. The turbidity data from the polymer curve can be seen below in Table 4 and Figure 4.

Table 4. NTU Data with Respect to Hydrex 6161 Dose

Flow	HLR	HRT	Coagulant	Dose	Polymer	Dose	pH		NTU			Backwash	
(gpm)	(gpm/ft^2)	(min)	Type	(mg/L)	Type	(mg/L)	Inf.	Eff.	Inf.	Eff.	% Rem.	Static (sec)	BW (sec)
33	2.0	18	$FeCl_3$	40	6161	0.60	7.31	6.88	8.84	4.95	44.0	16	32
						0.75	7.34	6.87	9.00	4.76	47.1	19	23
						0.90	7.34	6.90	9.08	4.34	52.2	24	21
						1.05	7.33	6.89	9.14	4.11	55.0	30	20

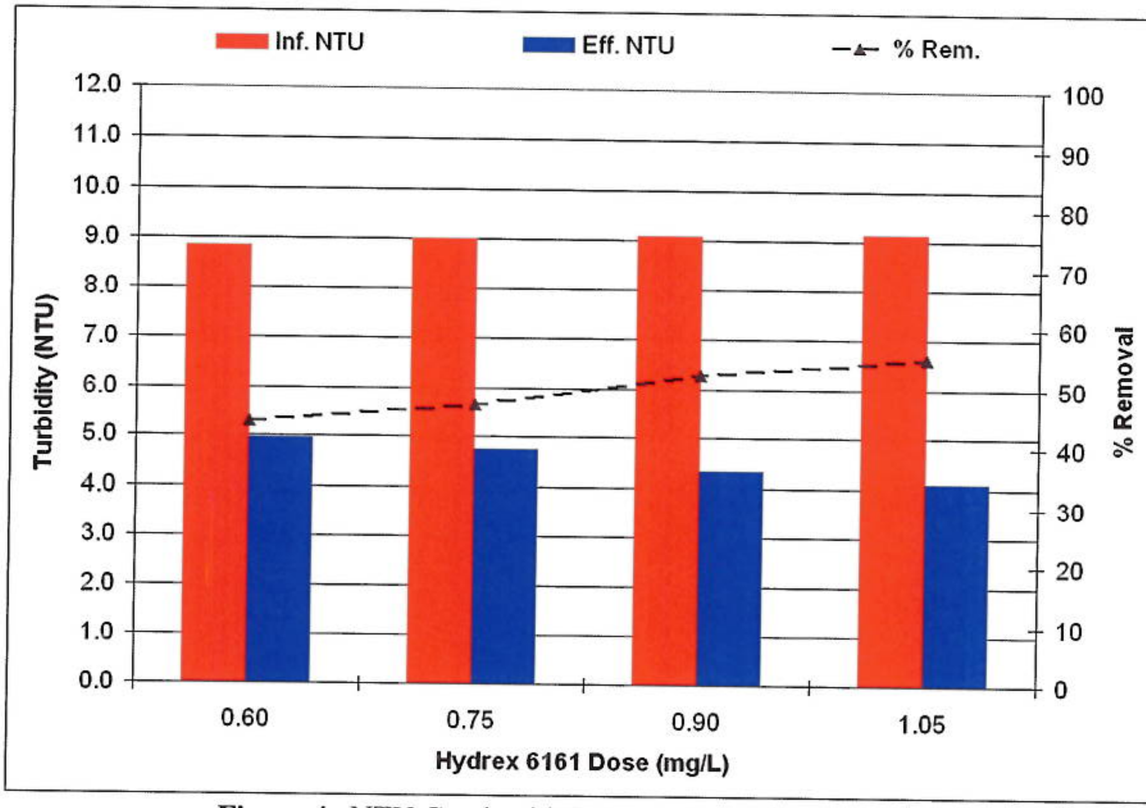

Figure 4. NTU Graph with Respect to Hydrex 6161 Dose

The lowest effluent turbidity was achieved at a polymer dose of 1.05 mg/L. The effluent turbidity was 4.11 NTU with a percent removal of 55%.

4.2 Ferric Chloride Testing

The first few days were dedicated to optimizing the ferric chloride (ferric) dose to achieve maximum effluent total phosphorus removal as well as find a dose that would maintain an effluent total phosphorus level of 0.35 mg/L. Each day 6-7 hourly samples were taken to form a composite sample in which no parameters were changed (coagulant dose, polymer dose, etc.) Ferric doses of 50, 55, 60, and 70 mg/L were used to achieve phosphorus removal goals over a 4-day period. The polymer dose and loading rate remained constant at 1.0 mg/L and 2.0 gpm/ft^2 (33 gpm) respectively. The data below in Table 5 and Figures 5 and 6 show the turbidity and total phosphorus removal during the ferric optimization curve.

Table 5. NTU and Total Phosphorus Data with Respect to $FeCl_3$ Dose

Flow	HLR	HRT	Coagulant	Dose	Polymer	Dose	pH		NTU			Backwash Static	BW	TP (mg/L)		
(gpm)	(gpm/ft^2)	(min)	Type	(mg/L)	Type	(mg/L)	Inf.	Eff.	Inf.	Eff.	% Rem.	(sec)	(sec)	Inf	Eff	% Rem
33	2.0	18	$FeCl_3$	50	6161	1.00	7.34	6.79	9.03	3.59	60.2	22	24	3.3	0.67	79.7
				55		1.05	7.36	6.78	9.03	2.64	70.8	27	22	3.5	0.46	86.9
				60		1.00	7.30	6.69	8.95	1.68	81.2	29	20	3.2	0.24	92.5
				70		1.00	7.35	6.60	9.16	0.99	89.2	30	20	3.3	0.10	97.0

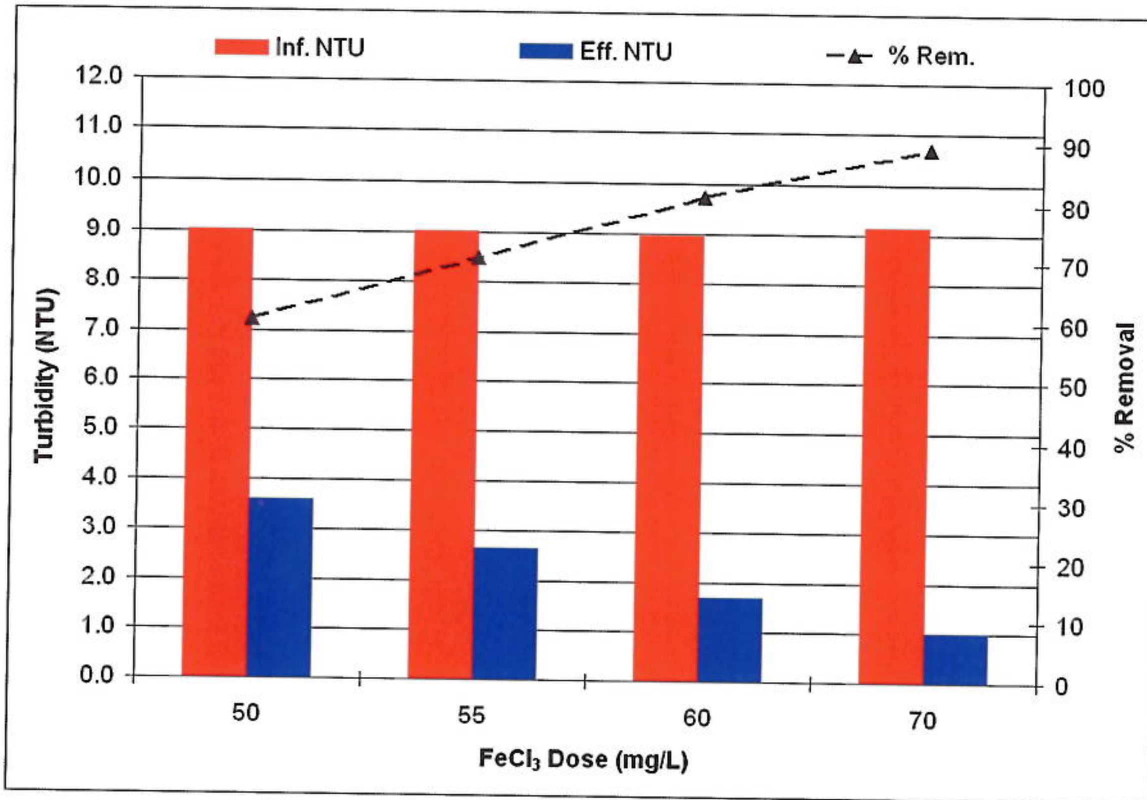

Figure 5. NTU Graph with Respect to $FeCl_3$ Dose

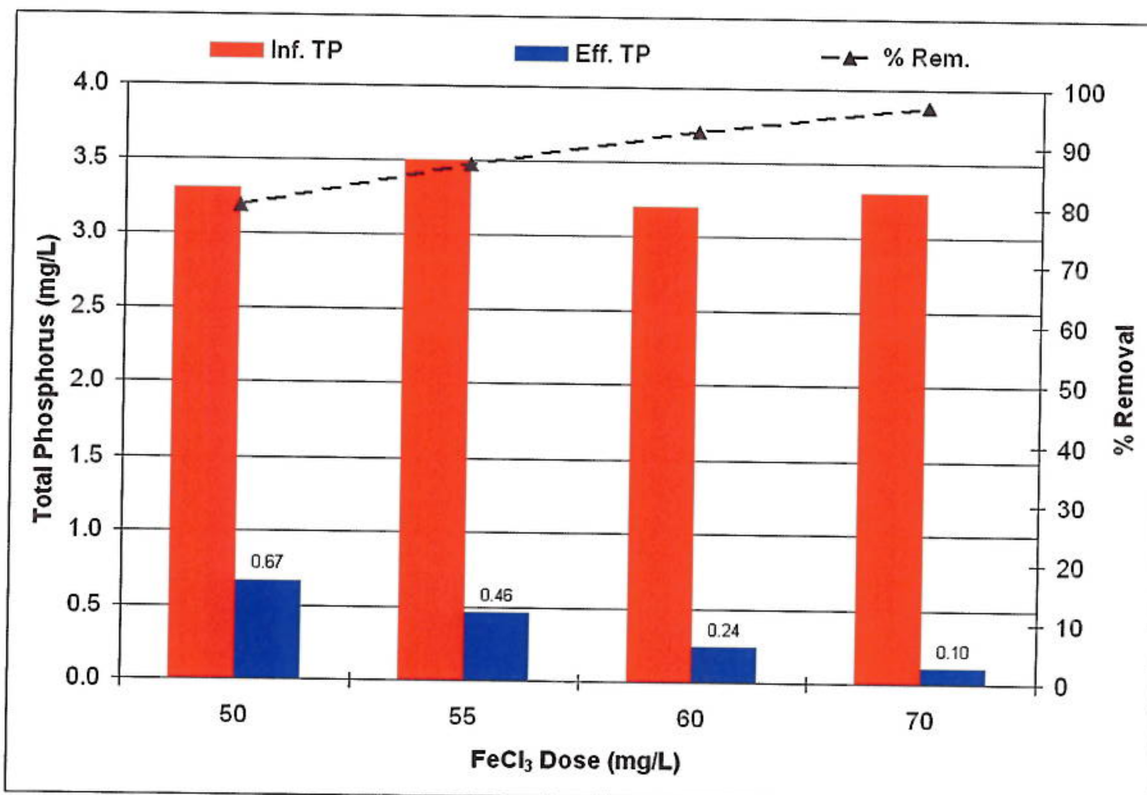

Figure 6. Total Phosphorus Graph with Respect to $FeCl_3$ Dose

The data in Figures 5 and 6 show that the highest turbidity and total phosphorus removal occurs at a ferric chloride dose of 70 mg/L. At 70 mg/L of ferric, the effluent turbidity was 1.0 NTU and effluent total phosphorus was 0.10 mg/L with percent removals of 90% and 97% respectively. Figure 6 shows a ferric dose between 55 and 60 mg/L would achieve the goal of maintaining a 0.35 mg/L effluent total phosphorus level.

4.3 Aluminum Sulfate Testing

The last five days of testing were performed using aluminum sulfate (alum) as the coagulant. Again chemical doses were changed once per day and were run for a period of 24 hours. However, composite samples were created from hourly grab samples taken during normal operating hours. The goals were the same as with the ferric chloride to achieve maximum effluent total phosphorus removal as well as find a dose that would maintain an effluent total phosphorus level of 0.35 mg/L. The polymer dose and loading rate remained constant at 1.0 mg/L and 2.0 gpm/ft^2 (33 gpm) respectively. Chemicals were dosed 24 hours a day during this optimization period allowing the Discfilter to achieve a steady state, in turn requiring less alum to achieve effluent total phosphorus goals. The influent total phosphorus also dropped from 3.5 mg/L to 3.0 mg/L or less. The turbidity and total phosphorus data can be seen in Table 6 and Figures 7 and 8.

Table 6. NTU and Total Phosphorus Data with Respect to $Al_2(SO_4)_3$ Dose

Flow	HLR	HRT	Coagulant		Polymer		pH		NTU			Backwash		TP (mg/L)		
				Dose		Dose						Static	BW			
(gpm)	(gpm/ft^2)	(min)	Type	(mg/L)	Type	(mg/L)	Inf.	Eff.	Inf.	Eff.	% Rem.	(sec)	(sec)	Inf	Eff	% Rem
33	2.0	18	$Al_2(SO_4)_3$	50	6161	1.00	7.41	7.05	10.80	1.52	85.9	24	24	3.1	0.34	89.0
				70		1.00	7.38	6.98	10.17	1.01	90.1	26	24	2.9	0.17	94.1
				75		1.00	7.36	6.95	9.44	2.34	75.2	10	87	3.3	0.36	89.1
				80		1.00	7.35	6.94	10.21	1.19	88.3	24	26	2.9	0.17	94.1

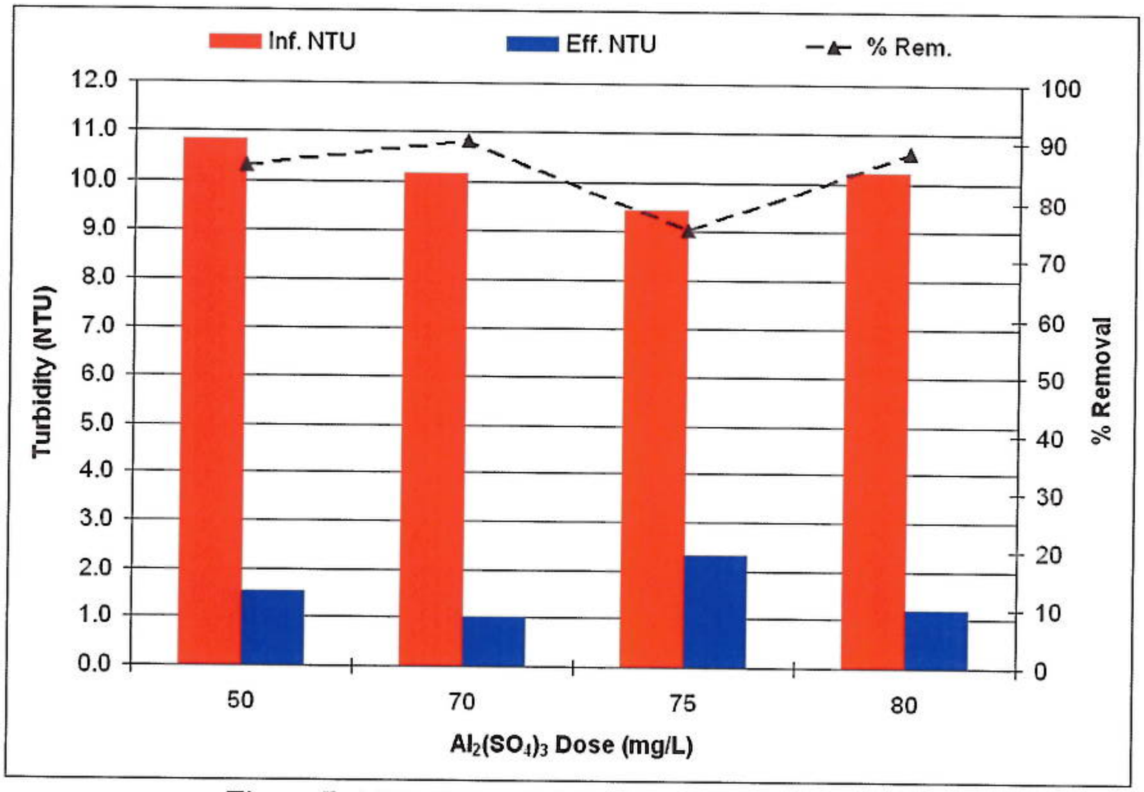

Figure 7. NTU Graph with Respect to $Al_2(SO_4)_3$ Dose

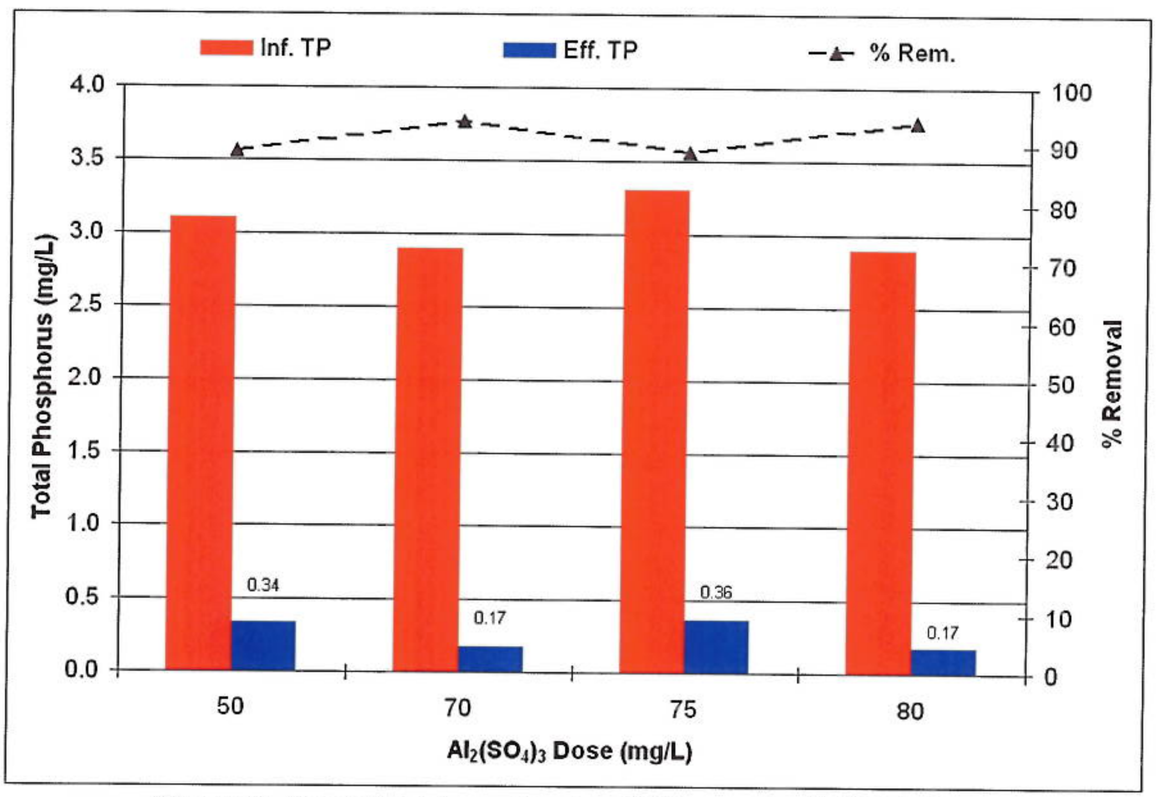

Figure 8. Total Phosphorus Graph with Respect to $Al_2(SO_4)_3$ Dose

The data in Figures 7 and 8 show that the highest turbidity percent removal was at an alum dose of 70 mg/L. At 70 mg/L of alum, the effluent turbidity was 1.0 NTU yielding 90% removal. The effluent total phosphorus at 70 mg/L of alum was 0.17 mg/L yielding a percent removal of 94%. Similar effluent total phosphorus removal was seen at 80 mg/L of alum as well. The Discfilter was able to achieve the effluent phosphorus goals. Depending on the influent total phosphorus level, the amount of alum required to achieve 0.35 mg/L of effluent total phosphorus will be between 50 and 75 mg/L.

4.4 Hydraulic Loading Rate and 40µm Filter Panel Testing

After several days of coagulant optimization, hydraulic loading rate curves were conducted using the 10µm filter panels. Loading rate curves were conducted using ferric chloride (ferric) and aluminum sulfate (alum) at loading rates of 2.0, 3.0, and 3.5 gpm/ft^2 (33, 50, and 58 gpm). At each parameter change, samples were collected for effluent total phosphorus. The influent total phosphorus was collected as a composite sample. The polymer dose stayed constant at 1.0 mg/L. The ferric dose was kept constant at 60 mg/L (based on previous data trying to achieve 0.35 mg/L effluent total phosphorus). At each change in hydraulic loading rate, chemical draw-downs were conducted for coagulant and polymer. The data below in Table 7 and Figures 9 and 10 display the loading rate curve with ferric chloride as the coagulant and 10µm filter panels.

Table 7. NTU and Total Phosphorus Data with Respect to HLR Using $FeCl_3$

Flow	HLR	HRT	Coagulant		Polymer		pH		NTU			Backwash		TP (mg/L)		
				Dose		Dose						Static	BW			
(gpm)	(gpm/ft^2)	(min)	Type	(mg/L)	Type	(mg/L)	Inf.	Eff.	Inf.	Eff.	% Rem.	(sec)	(sec)	Inf	Eff	% Rem
33	2.0	18	$FeCl_3$	60	6161	1.00	7.30	6.69	8.95	1.68	81.2	29	20	3.2	0.24	92.5
50	3.0	12		60		1.00	7.41	6.81	9.09	1.65	81.8	12	45	3.3	0.18	94.5
58	3.5	10		60		1.00	7.38	6.79	9.19	1.38	85.0	9	66	3.3	0.17	94.8

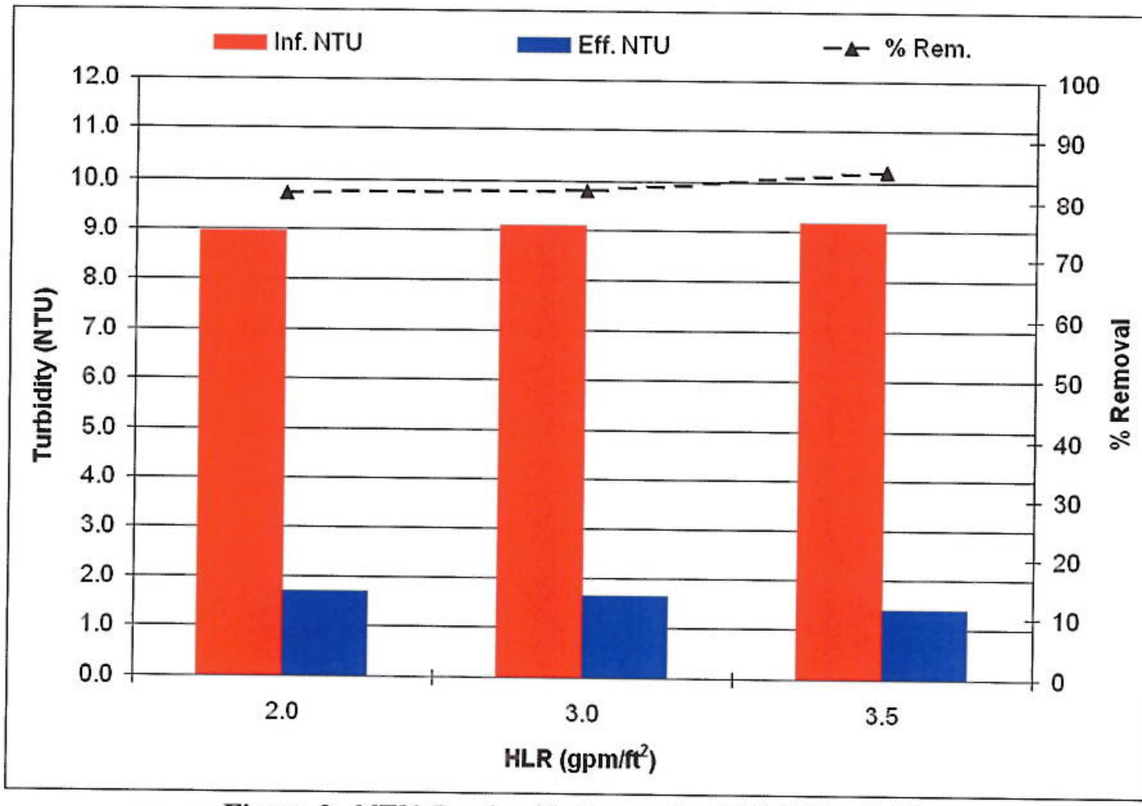

Figure 9. NTU Graph with Respect to HLR Using $FeCl_3$

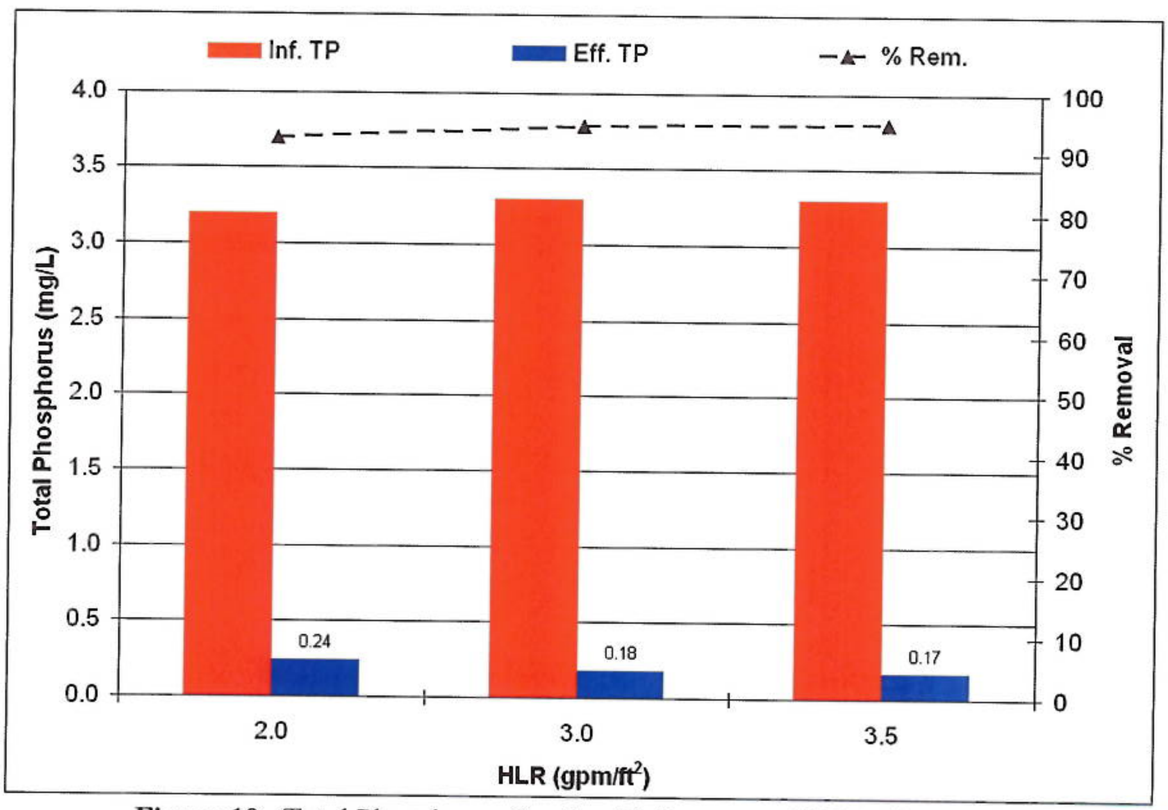

Figure 10. Total Phosphorus Graph with Respect to HLR Using $FeCl_3$

The data in Table 7 and Figures 9 and 10 show the Discfilter was able to meet the goal of less than 0.35 mg/L effluent total phosphorus at all loading rates tested. At a loading rate of 2 gpm/ft^2 (33 gpm), the static time was 29 seconds with a 20 second backwash time. 3.5 gpm/ft^2 (58 gpm) was the highest possible loading rate that could be achieved without blinding the panels on this Discfilter unit. Since the static time was only 9 seconds with a 66 second backwash time, the loading rate curve was stopped because a higher flow would have resulted in continuous backwashing or by passing of the filter panels which is not ideal for normal operation.

The same testing was performed using aluminum sulfate (alum) as the coagulant. Again, polymer was held constant at 1.0 mg/L and alum was dosed at 50 mg/L trying to maintain 0.35 mg/L effluent total phosphorus with the 10μm filter panels. The data can be seen in Table 8 and Figures 11 and 12 below.

Table 8. NTU and Total Phosphorus Data with Respect to HLR Using $Al_2(SO_4)_3$

Flow	HLR	HRT	Coagulant		Polymer		pH		NTU			Backwash		TP (mg/L)		
				Dose		Dose						Static	BW			
(gpm)	(gpm/ft^2)	(min)	Type	(mg/L)	Type	(mg/L)	Inf.	Eff.	Inf.	Eff.	% Rem.	(sec)	(sec)	Inf	Eff	% Rem
33	2.0	18	$Al_2(SO_4)_3$	50	6161	1.00	7.41	7.05	10.80	1.52	85.9	24	24	3.1	0.34	89.0
50	3.0	12		50		1.00	7.39	7.12	10.65	1.29	87.9	12	43	3.1	0.31	90.0
58	3.5	10		50		1.00	7.40	7.07	10.60	1.41	86.7	8	103	3.1	0.29	90.6

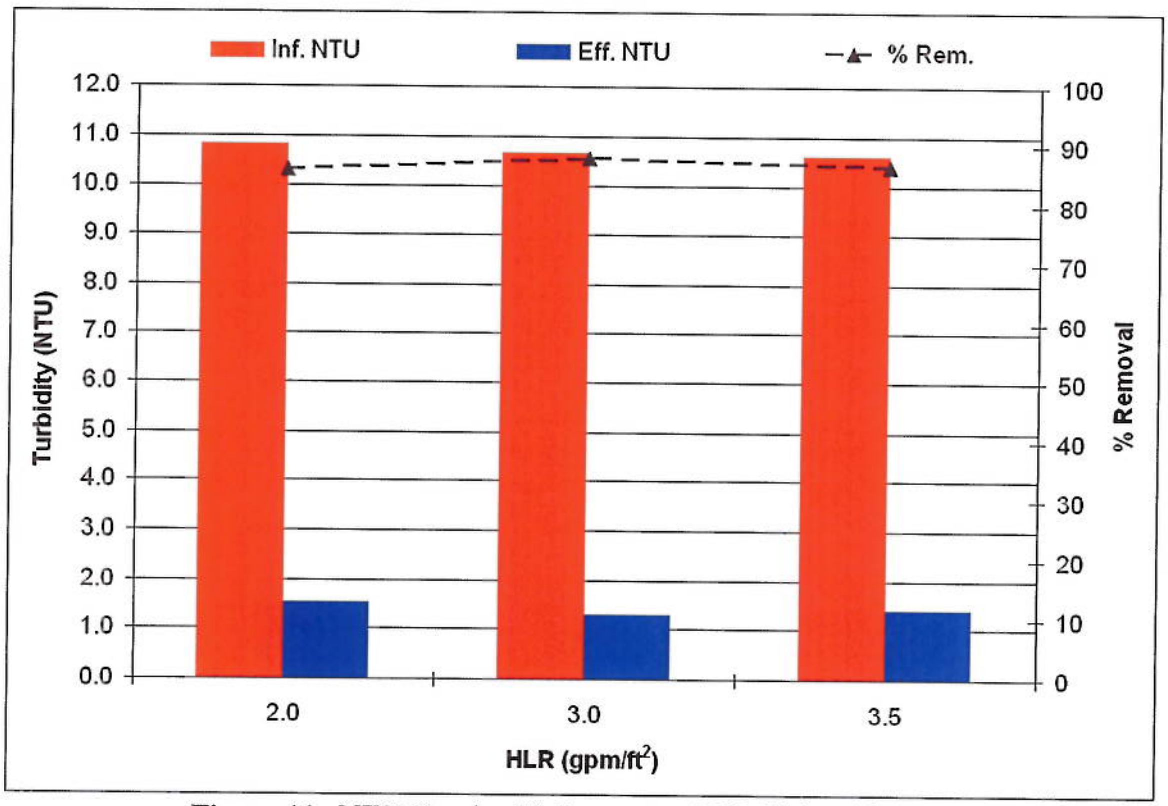

Figure 11. NTU Graph with Respect to HLR Using $Al_2(SO_4)_3$

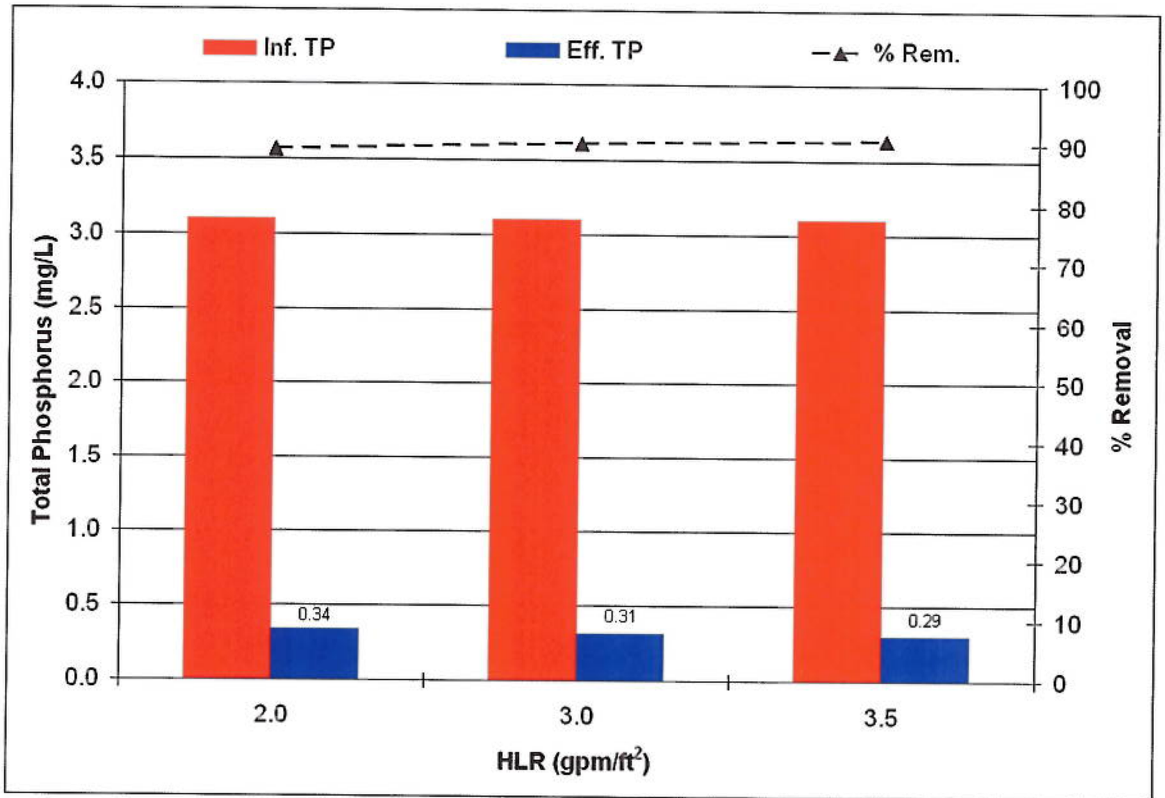

Figure 12. Total Phosphorus Graph with Respect to HLR Using $Al_2(SO_4)_3$

The data in Table 8 and Figures 11 and 12 show the Discfilter was able to meet the goal of less than 0.35 mg/L effluent total phosphorus at all loading rates tested. At a loading rate of 2 gpm/ft^2 (33 gpm), the static time was 24 seconds with a 24 second backwash time. 3.5 gpm/ft^2 (58 gpm) was the highest possible loading rate that could be achieved without blinding the panels on this Discfilter unit because the static time was only 8 seconds with over 1 minute of backwashing.

The last testing that occurred was similar to the aluminum sulfate loading rate curve except the filter panels were switched from 10µm to 40µm. This was performed to see if static times would improve and if the same total phosphorus removal would be achieved at the same operating parameters as the 10µm filter panels. The data can be seen below in Table 9 and Figures 13 and 14.

Table 9. NTU and Total Phosphorus Data with Respect to HLR Using 40µm Filter Panels

Flow	HLR	HRT	Coagulant		Polymer		pH		NTU			Backwash		TP (mg/L)		
				Dose		Dose						Static	BW			
(gpm)	(gpm/ft^2)	(min)	Type	(mg/L)	Type	(mg/L)	Inf.	Eff.	Inf.	Eff.	% Rem.	(sec)	(sec)	Inf	Eff	% Rem
33	2.0	18	$Al_2(SO_4)_3$	50	6161	1.00	7.33	7.08	10.80	4.12	61.9	28	20	3.1	0.79	74.5
50	3.0	12		50		1.00	7.39	7.05	10.90	3.70	66.1	13	32	3.1	0.65	79.0
58	3.5	10		50		1.00	7.42	7.13	10.60	3.51	66.9	11	40	3.1	0.63	79.7